Project Report: The Planetary Context of Biological Evolution: Geobiology of Neogene Hematitic Sedimentary Rocks

Lead Team:	***Harvard University***
Project Title:	***The Planetary Context of Biological Evolution: Geobiology of Neogene Hematitic Sedimentary Rocks***
Project Investigator:	***Andrew Knoll***

Project Progress

This year, we made important progress in understanding how aspects of life and environment become encrypted in hematitic sedimentary rocks being deposited in the Rio Tinto region of southwestern Spain. Precambrian iron formations and Martian hematite share a need for careful studies of modern analog ecosystems where biological and physical processes can be tied directly to paleobiological and geochemical patterns in deposited iron−rich sediments. The Rio Tinto drainage area of southern Spain offers just such an opportunity.

During the past funding year, we completed two field sessions in the Rio Tinto region with colleagues from the Spanish Centro de Astrobiologia (CAB). Using a combination of petrology, Moessbauer spctroscopy and X−ray diffraction (XRD), we established that iron sediments precipitated from Rio Tinto waters are primarily hydronium jarosite, with unusual Fe−sulfates such as copiapite and poorly ordered iron oxides forming late in the season, when water pools evaporate to dryness. Early in diagenesis, highly soluble jarosites are replaced by goethite, which has a high capacity for preserving cellular details of cells and tissues caught up in Rio Tinto sediments. In ca. 300,000 year old terraces, much goethite has, in turn, been replaced by hematite, some of which is coarse grained. Thus, through diagenesis, Rio Tinto sediments come to resemble hematites observed on the Martian surface. Comparison of modern and Pleistocene sediments also shows that aspects of physical and biological environment are encrypted in the textures of Fe−sediments, providing a basis for the interpretation of images returned from the Mars Exploration Rover (MER).

Highlights

- Diagenetically stablized, iron−rich sedimentary rocks at Rio Tinto, Spain, resemble Martian hematite in mineralogy and inferred crystal

size. The terrestrial rocks also preserve physical and chemical markers of life and environment that may help to constrain interpretations of data acquired during the 2003 Mars MER rover mission.

Roadmap Objectives

- ***Objective No. 5:*** Linking Planetary Biological Evolution
- ***Objective No. 8:*** Past Present Life on Mars

Mission Involvement

*Mission Class**	*Mission Name (for class 1 or 2) OR Concept (for class 3)*	*Type of Involvement***
1	Mars MER	AHK is a Co−I on 2003 Mars MER. John Grotzinger was also recently appointed a Participating Scientist on the Mars MER Science Team.

* Mission Class: Select 1 of 3 Mission Class types below to classify your project:
1. Now flying OR Funded & in development (e.g., Mars Odyssey, MER 2003, Kepler)
2. Named mission under study / in development, but not yet funded (e.g., TPF, Mars Lander 2009)
3. Long−lead future mission / societal issues (e.g., far−future Mars or Europa, biomarkers, life definition)

** Type of Involvement = Role / Relationship with Mission
Specify one (or more) of the following: PI, Co−I, Science Team member, planning support, data analysis, background research, instrument/payload development, research or analysis techniques, other (specify).

This subproject relates directly to the 2003 Mars MER lander mission. The primary landing site for this mission is a region where, as inferred from remote sensing, aqueous hematite was deposited early in Mars' history. Study of this potential Earth analog will both direct and constrain interpretation of images and chemical analyses from Mars.

Samples of Rio Tinto rocks are being used in the calibration of Mars MER instruments.

Field Expeditions

Field Trip Name: Rio Tinto hematite geobiology	
Start Date: 09/05/2001	***End Date:*** 09/17/2001
Continent: Europe	***Country:*** Spain

State/Province: Huelva	***Nearest City/Town:*** Huelva
Latitude: 38 N	***Longitude:*** 7 W
Name of site(cave, mine, e.g.): river system	***Keywords:*** hematite, geobiology, sedimentary geology, Mars
Description of Work: Description of work: Collected samples of modern sediments, water, and ancient iron−rich sedimentary rocks from Rio Tinto for petrological, chemical, and paleobiological analysis Also, collected samples across Proterozoic−Cambrian boundary in south−central Spain	
Members Involved: A.H. Knoll	

Field Trip Name: Rio Tinto hematite geobiology	
Start Date: 05/27/2002	***End Date:*** 06/05/2002
Continent: Europe	***Country:*** Spain
State/Province: Huelva	***Nearest City/Town:*** Huelva
Latitude: 38 N	***Longitude:*** 7 W
Name of site(cave, mine, e.g.): river system	***Keywords:*** hematite, geobiology, sedimentary geology, Mars
Description of Work: Collected additional samples of modern sediments, water, and ancinet iron−rich sedimentary rocks from Rio Tinto for petrological, chemical, and paleobiological analysis.	
Members Involved: A.H. Knoll	

Cross Team Collaborations

This project is being carried out in collaboration with the Spanish CAB. Riccardo Amils leads CAB's research on Rio Tinto microbiology, and David Fernandez spearheads their geological work on Rio Tinto rocks. To date, we have completed two joint field excursions, and David has traveled to the US.